

N₂- and air-broadened linewidths and frequency-shifts of N₂O

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ABSTRACT

N_2 - and air-broadened linewidths and pressure-induced frequency-shifts of N_2O were measured from spectra of room temperature gas samples. The data were obtained with a high resolution Fourier Transform spectrometer in the region between 1800 and 4800 cm^{-1} . Over 500 vibration-rotation lines were measured from which linewidth coefficients were accurately determined ($<2\%$ on the average) for $1 \leq |m| \leq 73$. The shift coefficients were found to have a weak J dependence in which the magnitude of the coefficients increases in proportion to J for a given vibrational band. Further, the results show that the shift coefficients exhibit a line frequency dependence which follows from theory. In general, N_2 - or air-broadened shift coefficients (which were found to be comparable in value for a given line) range from about $-.001$ to almost $-0.005 \text{ cm}^{-1}/\text{atm}$. for the lines covered in this study.

1. INTRODUCTION

The present work complements an earlier study¹ which involved measurements of self-broadened linewidths and frequency-shifts of N₂O in the 1800 to 2630 cm⁻¹ spectral region. The present work includes N₂- and dry air-broadened linewidths and frequency-shifts of N₂O for the 1800 to 4800 cm⁻¹ region. In the previous paper¹, line strengths were determined for several of the bands in the 900 to 3600 cm⁻¹ region including bands of several isotopic species of N₂O. The measurements and analysis of the line strengths of the higher frequency bands observed in this work (3600-4800 cm⁻¹) will be included in a following paper. The low pressure line positions of many N₂O isotopic species for several ground state and hot bands between 900 and 4700 cm⁻¹ were reported by Toth² and included the vibration-rotation parameters of all of the transitions measured here which included the 20011-00001 band of ¹⁴N₂¹⁶O centered at 4730.82501 cm⁻¹. The vibrational-state notation used here is v₁v₂ℓV_s with the upper state given first in the description of the vibrational transitions. s denotes e or f and pertains to the vibrational angular momentum quantum number, ℓ, where s=1 for e and s=2 for f.

The linewidth results are compared to values given by Lacome et al.³ and air-broadened values listed in the HITRAN⁴ compilation. Lacome et al.³ obtained high resolution measurements of self-, N₂-, and O₂ broadening of N₂O at room temperature and 220 K, and the reported uncertainty of the measured linewidths were less than 4%. The air-broadened values representing the results of Lacome et al.³

were computed from the combination of their N₂- and O₂-broadened linewidths.

There have been no reports of pressure-induced frequency shifts of N₂O due to foreign gas broadening. However self-broadened shifts have been reported by Toth¹ and Pollock et al.⁵. Toth¹ determined the pressure-shift coefficients for 136 lines in the 1836 to 2504 cm⁻¹ region and found that the coefficients have a weak J dependence. Pollock et al.⁵ obtained the shift coefficients of three lines in the 00021-00001 band and one line in the 12011-00001 band of ¹⁴N₂¹⁶O using heterodyne measurement techniques.

2. EXPERIMENT

The spectra were obtained with a Fourier-transform spectrometer (FTS) located in the McMath solar telescope facility at the Kitt Peak National Observatory. All data were obtained with an unapodized spectral resolution of 0.011 cm⁻¹ and other experimental conditions are listed in Table 1. The N₂O, N₂ and dry air gas samples came from cylinders containing high purity samples. No detectable CH₄ and CO features were observed in any of the spectral data however broadened lines of CO₂ were observed in the strong v₃ band region and this was found to be due to the CO₂ content in the open spaces between the IR source (quartz-iodine projection lamp) and the entrance to the vacuum tank which enclosed the FTS. The open space was purged with dry N₂, which greatly reduced the air-broadened H₂O contributions observed in the

spectra. Narrow, low-pressure H₂O contributions were observed on top of the pressure-broadened counter-parts and the center frequencies of the narrow features were easily measured with high accuracy with the aid of the computer soft-ware used in this study. The low pressure H₂O absorptions were due to the low content (~200 μm) of air in the vacuum tank and the frequency measurements of several of these lines were used as frequency calibration standards for the determination of the N₂O broadened line center positions.

Figures 1-4 show compressed scans of the run representing 292.2 Torr of N₂ and covering the spectral regions of N₂O observed in this study. The signal-to-noise ratio of all the spectra was about 400 to 1 throughout the total spectral region. Figures 1 and 3 show irregular features and these are due to H₂O absorptions. A very compressed scan covering the 1800 to 4800 cm^{-1} region is displayed in Figure 4 which shows the optical pre-filter characteristics and the observed intensity of the CO₂ v_3 band in the 2280-2380 cm^{-1} region. The wide features shown in the figure from about 2850 to 3000 cm^{-1} are artifacts due to the optical filter. The CO₂ pressure-broadened lines were measured from several spectra and a comparison of the results with CO₂ half-width coefficients given in the HITRAN⁴ listing indicate that the broadening pressure was about 600 Torr which is the ambient air pressure in the open spaces.

Sample temperatures were inferred from readings of thermistor probes in thermal contact with the absorption cell and the sample pressures were measured with a Baratron gauge: 10 Torr head for N₂O

measurements and 1000 Torr head for total (N_2O +buffer gas) pressure measurements. The 1000 Torr head was calibrated against room air pressure (about 600 Torr) which, in turn, was measured to high accuracy with a mercury manometer. The N_2O partial pressures were checked against the values derived from line strength measurements of the spectra using line strength values given in ref. (1). This comparison showed good agreement which indicates that the N_2O pressure measurement reading after the initial fill (N_2O) of the absorption cell for a given run was an accurate determination of the N_2O content after the buffer gas was let into the cell.

3. SPECTRAL ANALYSIS

The parameters were retrieved from the spectra using a non-linear least-squares (NLLS) curve-fitting technique which corrects, if necessary, the input values of positions, strengths and widths in the synthetic spectrum in order to minimize differences between the observed and computed spectra. This computer algorithm has been applied in several studies including previous N_2O studies^{1,2}. The observed spectra, for which the conditions are given in Table 1, were transformed from 12 or more co-added interferograms per run into spectral data at the Kitt Peak facility. The spectra were transferred to JPL by computer transmission.

The linewidth broadening coefficient, b° , is related to the measured linewidth, b , by the relation:

$$b = b^o_f p_f + b^o_s p_s$$

$$p_T = p_s + p_f, \quad (1)$$

where b^o_f and b^o_s are the foreign and self-broadened width coefficients (in $\text{cm}^{-1}/\text{atm.}$), respectively, and p_f and p_s are the foreign and self-broadened partial pressures and p_T is the total pressure. b , b^o_f , and b^o_s pertain to the Lorentz half-width at half-height (HWHH). The foreign broadening coefficients, b^o_f , were derived from the measurements, values of b^o_s given in ref. (1), the pressures given in Table 1, and eq. (1). The averaged value of b^o_f for either air or N_2 broadening was derived for a given line from the measurements along with the estimated uncertainty. The results were grouped in terms of $|m|$ where $m=J''+1$ for R-branch transitions and $m=-J''$ for P-branch lines. On the average, no differences were observed between P- and R-branch lines with the same value of $|m|$ for a given vibrational band and, with several bands included in the analysis, a vibrational dependence was not found for the b^o_f 's for either air- or N_2 -broadening. The same result was also found for self-broadened linewidths¹.

The pressure-induced frequency shifts, d , given in cm^{-1} , can be expressed in a form similar to eq. (1) as:

$$d = d^o_f p_f + d^o_s p_s, \quad (2)$$

where d^o_f and d^o_s are the foreign and self-broadened shift coefficients, respectively and given here in $\text{cm}^{-1}/\text{atm.}$ d is the

difference between the line center position frequency at pressure p_T and that at zero pressure. The measured line positions of the spectral runs given in Table 1 were calibrated and corrected from measured $H_2^{16}O$, narrow (low pressure) absorptions observed in the spectra. The $H_2^{16}O$ frequencies were known from values computed from vibration-rotation energy levels given by Toth for the (010)-(000) band⁶ and the (100)-(000) and (001)-(000) bands⁷. The zero pressure N_2O line frequencies were calculated from parameters given in a previous study². The self-broadened frequency shifts of N_2O obtained in previous studies^{1,5} covered vibration-rotation transitions that were not measured here. Nevertheless, it was determined in the present study that the magnitude and direction of d_s^o for a given N_2O line is similar to that of $d^o(\text{air})$ or $d^o(N_2)$ for the line. Therefore, for this study, the shift coefficients were derived from the relation:

$$d = d_f^o \times p_T . \quad (3)$$

This should yield accurate results for d_f^o since contributions of $d_s^o \times p_s$ to d are small (about 3% or less) for the runs used in this exercise.

4. RESULTS

In two N_2O studies^{1,3}, the linewidths were plotted against $|m|$ from which smoothed values of b^o were derived. For this study, a smoothing function was applied:

$$b_f^o \text{ (smoothed)} = A \exp[\sum_j b(j)x(j)],$$

where $x(j) = |m|^{j-1}$

and $A = 1\text{cm}^{-1}/\text{atm.}$, (4)

in which the $b(j)$'s were determined from a least-squares fit of the individual b_f^o 's obtained from the measurements and eq.(1). The b_f^o 's included in the analysis were derived from the most accurately determined observed values having estimated uncertainties in b_f^o of $0.002\text{cm}^{-1}/\text{atm.}$ or less. These results were combined and averaged in terms of $|m|$ values and broadening agent and these sets were labeled "measured" b_f^o . Also sets of uncertainties to b_f^o (measured) termed Δb_f^o (measured) were established. The b_f^o (measured) were used in the analysis involving the smoothing function. The parameters, $b(j)$, obtained from the analysis for N_2 and air-broadening are given in the first two columns of Table 2. It was determined that five parameters were sufficient to adequately simulate the linewidth coefficients for the range of $|m|$ values (1-73) included in the analysis.

Also listed in Table 2 are parameters derived from the analysis of the pressure-induced frequency shifts using an empirical expression:

$$d^o(\text{computed}) = A\{d(1) + d(2)|m| + d(3)v\},$$

where v is the line frequency in cm^{-1}

and $A = 1\text{cm}^{-1}/\text{atm.}$ (5)

The measured d^o_f 's used in the analysis had estimated uncertainties, $|\Delta d^o_f|$, of $0.0003\text{cm}^{-1}/\text{atm}$. or less.

The half-width results for N_2 - and air-broadening are given in Table 3. The table includes b^o_f (smoothed), b^o_f (measured), and within parentheses, Δb^o_f (measured) values from this study along with smoothed values of $b^o(\text{N}_2)$ and $b^o(\text{air})$ obtained by Lacome et al.³ and $b^o(\text{air})$ given in the HITRAN listing⁴ for the v_3 band of N_2O . Lacome et al.³ did not measure air-broadening of N_2O but rather N_2 - and O_2 -broadening and the values given in Table 3, representing their air-broadened linewidths, were derived from their smoothed values of $b^o(\text{N}_2)$ and $b^o(\text{O}_2)$ and the expression:

$$b^o(\text{air}) = 0.78b^o(\text{N}_2) + 0.22b^o(\text{O}_2), \quad (6)$$

which is an accurate approximation considering that dry air is composed of 77% N_2 , 21% O_2 , 1% argon by volume and minute quantities of other gases.

The smoothing function used to obtain the smoothed results for this work and listed in Table 3 produced values which were slightly less than adequate for $|m|=1$ with the difference between the measured and smoothed value equal to about 2% for either N_2 - or air-broadening, however, on the average, the smoothed values gave a very accurate representation of the observed results. A comparison of the values between this work and those of Lacome et al.³ shows very good agreement for both N_2 - and air-broadening for the range of measurements given in their study ($|m| \leq 53$ for N_2 and

$|m| \leq 49$ for O_2 broadening). The HITRAN⁴ air-broadened values appear to have been computed from the values given by Lacome et al.³ and, therefore, are in good agreement with those of this study for $|m| \leq 49$ but are higher than those given here for $|m| > 49$ with differences proportional to $|m| - 49$.

Due to strong blending of lines or saturated or very weak absorptions, not all observed N_2O lines were included in the analyses. In total over 500 lines were included of which transitions of the more accurately measured values of b° and d° are listed in Table 4. The table includes the zero pressure line frequency², observed and smoothed values of $b^\circ(N_2)$ and $b^\circ(\text{air})$, observed and computed values of $d^\circ(N_2)$ and $d^\circ(\text{air})$, the upper and lower vibrational states and molecule notation. The molecule notation is as follows: $446 = ^{14}N_2^{16}O$, $456 = ^{14}N^{15}N^{16}O$, $546 = ^{15}N^{14}N^{16}O$, etc. For a given line, the uncertainties given within parentheses were based upon the agreement of the values of b° and d° derived from the various spectral runs and the observed values were determined from averaging the values obtained from the spectra for that line. The smoothed values of $b^\circ(N_2)$ and $b^\circ(\text{air})$ listed in the table were derived from the parameters given in Table 2 and eq. (4) and are also listed in Table 3. The computed values of $d^\circ(N_2)$ and $d^\circ(\text{air})$ were based upon the parameters given in Table 2 and eq. (5). The expression given in eq. (5) relates very little to theory and was used basically to show the trend of the d° 's in terms of line frequency and J value. A study of the line-shift results shows that on the average for a given line, $d^\circ(N_2) \sim d^\circ(\text{air})$. Also, the shift

coefficients exhibit a weak J dependence in which the magnitude of the coefficients increases in proportion to J or $|m|$ for a given vibrational band. Further, the results show that the shift coefficients exhibit a line frequency dependence which follows from theory.

Table 4 includes a few transitions of the rare isotopic species, $^{14}\text{N}^{15}\text{N}^{16}\text{O}$, as well as 18 hot band lines. Also included are the highly perturbed lines, P47 and R45, of the 10011-00001 band of $^{14}\text{N}_2^{16}\text{O}$ situated at 3430.203 and 3507.997 cm^{-1} , respectively, and one of the two interacting transitions, R45, of the 06001-00001 band located at 3508.154 cm^{-1} . The observed linewidth and shift coefficients for the two lines of the 10011-00001 band appear not to be altered by the perturbation however this was not the case for the interacting line. The observed linewidth coefficients for this line were about 3% and 5% lower than the N_2 - and air-broadened smoothed values, respectively. The observed frequency-shifts were found to be $-0.0015(5)$ $\text{cm}^{-1}/\text{atm}$. for both broadening agents whereas the computed values are -0.00394 and -0.00395 $\text{cm}^{-1}/\text{atm}$. which are in good agreement with the observed shift coefficients of the R45 line of the 10001-00001 band: $-0.00424(5)$ and $-0.00410(10)$ $\text{cm}^{-1}/\text{atm}$. for N_2 - and air-broadening, respectively.

5. CONCLUSION

The linewidths (HWHH) and pressure-induced frequency shifts of N_2O broadened by N_2 and dry air were measured to high accuracy for gas samples at room temperature. The observations covered

vibration-rotation transitions from 1800 to 4800 cm^{-1} with over 500 lines measured with rotational transitions extending to lower state J equal to 73. A smoothing function was applied to the measured linewidth coefficients, b° , and the smoothed values derived from the analysis give an accurate representation of the N_2 and air broadened observed b° 's. These results are in good agreement with the linewidth values of Lacome et al.³ and with the HITRAN⁴ air-broadened half-width coefficients given for the v_3 band for $|m| < 50$. The measurements by Lacome et al.³ were limited to lines of $|m| \leq 53$ for N_2 broadening and $|m| \leq 49$ for O_2 broadening and the air-broadened values representing their work were computed from their N_2 - and O_2 - broadened results. The HITRAN⁴ air-broadened values appear to have been computed from the values given by Lacome et al.³ and, therefore, are in good agreement with those of this study for $|m| \leq 49$ but are higher than those given here for $|m| > 49$ with differences proportional to $|m| - 49$.

An empirical expression was used in the analysis of the measured pressure-induced frequency shift coefficients, d° . The expression was not based on theory and was used to show the trend of the d° 's in terms of J within a vibrational band and in terms of the line frequencies. The analysis shows that the shift coefficients exhibit a weak J dependence in which the magnitude of the coefficients increases in proportion to J or $|m|$ for a given vibrational band. Further, the results show that the shift coefficients exhibit a line frequency dependence which follows from theory. In general, the d° 's for either N_2 - or air-broadening

(which are comparable in value for a given line) range from about -0.001 to almost -0.005 $\text{cm}^{-1}/\text{atm}$. for the lines covered in this study. These range of values also cover N_2O self-broadened line shift results reported by Toth¹ for the 1800-2360 cm^{-1} region and by Pollock et al.⁵ who obtained the shifts of four lines in the 4300-4750 cm^{-1} region.

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FIGURE CAPTIONS

Figure 1. Compressed scan of N_2O broadened by N_2 from 1800 to 2300 cm^{-1} . The path length was 1.5m, the N_2O partial pressure was 8 Torr and the N_2 pressure was 292.2 with the gas sample at 296 K. Two N_2O ground state bands are shown and the irregular features are due to H_2O .

Figure 2. Compressed scan of N_2O broadened by N_2 from 2400 to 2900 cm^{-1} . The path length was 1.5m, the N_2O partial pressure was 8 Torr and the N_2 pressure was 292.2 with the gas sample at 296 K. Three N_2O ground state bands are shown.

Figure 3. Compressed scan of N_2O broadened by N_2 from 3300 to 3900 cm^{-1} . The path length was 1.5m, the N_2O partial pressure was 8 Torr and the N_2 pressure was 292.2 with the gas sample at 296 K. Five N_2O ground state bands are shown and the irregular features are due to H_2O .

Figure 4. Compressed scan of N_2O broadened by N_2 showing the entire spectral region covered from 1800 to 4800 cm^{-1} . The path length was 1.5 m, N_2O partial pressure 8 Torr and N_2 pressure 292.2 Torr. The broad features which appear in the 2850 to 3000 cm^{-1} region are due to artifacts in the optical filter. The evenly spaced absorptions observed between 2280 and 2380 cm^{-1} are due to the v_3 band of CO_2 . Irregular features mainly occurring in the 1800 to 2000 cm^{-1} region and the 3550 to 3950 cm^{-1} are due to H_2O .

Table 1. Experimental Conditions

Path (m)	Sample pressures (Torr)		Temp. (K)	Broadening gas
	N ₂ O	Broadener		
1.5	8.02	292.2	296	N ₂
1.5	8.02	392.1	296	N ₂
1.5	8.02	492.2	296	N ₂
1.5	8.02	292.2	296	dry air
1.5	8.08	391.1	296	dry air
1.5	8.08	490.9	296	dry air

Table 2. Parameters derived for calculating smoothed values of half-width coefficients, b° , and computed frequency-shift coefficients, d° for N_2 - and air-broadening of N_2O

j	half-width parameters		frequency-shift parameters	
	N_2	air	N_2	air
1	-2.301×10^0	-2.324×10^0	1.388×10^{-3}	1.140×10^{-3}
2	-2.118×10^{-2}	-2.214×10^{-2}	-4.321×10^{-5}	-3.715×10^{-5}
3	5.460×10^{-4}	5.671×10^{-4}	-9.517×10^{-7}	-9.653×10^{-7}
4	-6.642×10^{-6}	-6.716×10^{-6}		
5	2.808×10^{-8}	2.614×10^{-8}		

$b^\circ(\text{smoothed}) = A \exp[\sum a(j)b(j)]$; $x(j) = |m|^{j-1}$

$d^\circ(\text{computed}) = A\{d(1) + d(2)\times|m| + d(3)\times v\}$, $v=\text{line frequency in cm}^{-1}$
the parameters given above are unitless except $d(3)$ which is $/cm^{-1}$
and A is $1cm^{-1}/atm$.

Table 3. Smoothed and measured values of N_2 and air broadened half-width coefficients, b° ($\text{cm}^{-1}/\text{atm.}$ at 296 K), of N_2O given with values from other studies

m	N_2 broadening			air broadening			Lacome et al. ^c	m
	smoothed	this work measured	Lacome et al. ^a	smoothed	this work measured	HITRAN ^b		
1	0.09814	0.1002(18.)	0.10090	0.09579	0.0979(24.)	0.0974	0.09726	1
2	0.09624	0.0952(7.)	0.09527	0.09385	0.0932(7.)	0.0927	0.09258	2
3	0.09446	0.0938(7.)	0.09260	0.09204	0.0918(6.)	0.0903	0.09017	3
4	0.09282	0.0923(10.)	0.09070	0.09036	0.0890(8.)	0.0885	0.08836	4
5	0.09128	0.0903(6.)	0.08920	0.08880	0.0876(9.)	0.0870	0.08688	5
6	0.08986	0.0900(6.)	0.08788	0.08735	0.0871(4.)	0.0857	0.08555	6
7	0.08853	0.0882(9.)	0.08670	0.08600	0.0855(3.)	0.0845	0.08435	7
8	0.08729	0.0874(7.)	0.08563	0.08474	0.0852(5.)	0.0834	0.08325	8
9	0.08614	0.0860(5.)	0.08464	0.08357	0.0836(7.)	0.0823	0.08222	9
10	0.08507	0.0855(9.)	0.08372	0.08248	0.0827(9.)	0.0814	0.08127	10
11	0.08407	0.0842(5.)	0.08287	0.08147	0.0823(5.)	0.0805	0.08038	11
12	0.08315	0.0833(4.)	0.08207	0.08053	0.0807(6.)	0.0797	0.07955	12
13	0.08228	0.0828(7.)	0.08132	0.07966	0.0799(8.)	0.0789	0.07877	13
14	0.08148	0.0818(4.)	0.08063	0.07885	0.0794(6.)	0.0782	0.07805	14
15	0.08074	0.0812(6.)	0.07997	0.07809	0.0784(3.)	0.0775	0.07736	15
16	0.08004	0.0807(6.)	0.07935	0.07739	0.0775(9.)	0.0768	0.07672	16
17	0.07940	0.0792(4.)	0.07877	0.07674	0.0772(7.)	0.0762	0.07612	17
18	0.07880	0.0788(8.)	0.07823	0.07614	0.0762(6.)	0.0757	0.07556	18
19	0.07824	0.0784(4.)	0.07772	0.07558	0.0756(5.)	0.0752	0.07503	19
20	0.07773	0.0776(8.)	0.07724	0.07506	0.0752(5.)	0.0747	0.07454	20
21	0.07725	0.0773(6.)	0.07679	0.07458	0.0746(6.)	0.0742	0.07408	21
22	0.07680	0.0767(5.)	0.07637	0.07413	0.0740(8.)	0.0738	0.07365	22
23	0.07639	0.0764(6.)	0.07597	0.07371	0.0736(5.)	0.0734	0.07325	23
24	0.07600	0.0756(7.)	0.07560	0.07333	0.0732(5.)	0.0730	0.07287	24
25	0.07564	0.0754(4.)	0.07525	0.07297	0.0726(4.)	0.0726	0.07252	25
26	0.07531	0.0750(4.)	0.07493	0.07263	0.0725(4.)	0.0723	0.07220	26
27	0.07500	0.0745(8.)	0.07463	0.07232	0.0720(9.)	0.0720	0.07190	27
28	0.07471	0.0746(9.)	0.07435	0.07203	0.0716(11.)	0.0717	0.07162	28
29	0.07443	0.0744(6.)	0.07409	0.07176	0.0716(5.)	0.0715	0.07136	29
30	0.07418	0.0741(6.)	0.07385	0.07151	0.0714(6.)	0.0712	0.07112	30
31	0.07394	0.0739(5.)	0.07364	0.07127	0.0711(8.)	0.0710	0.07091	31
32	0.07372	0.0741(7.)	0.07344	0.07105	0.0708(12.)	0.0708	0.07071	32
33	0.07350	0.0733(7.)	0.07327	0.07084	0.0708(7.)	0.0707	0.07054	33
34	0.07330	0.0735(8.)	0.07311	0.07064	0.0703(11.)	0.0705	0.07037	34
35	0.07311	0.0732(8.)	0.07298	0.07045	0.0706(9.)	0.0704	0.07023	35
36	0.07293	0.0732(8.)	0.07287	0.07027	0.0702(11.)	0.0702	0.07011	36
37	0.07275	0.0727(8.)	0.07278	0.07009	0.0702(7.)	0.0701	0.07001	37
38	0.07259	0.0726(13.)	0.07272	0.06992	0.0702(9.)	0.0700	0.06993	38
39	0.07242	0.0724(10.)	0.07267	0.06975	0.0700(5.)	0.0700	0.06985	39
40	0.07226	0.0722(4.)	0.07266	0.06959	0.0694(10.)	0.0699	0.06981	40
41	0.07210	0.0715(6.)	0.07264	0.06943	0.0693(5.)	0.0699	0.06976	41
42	0.07195	0.0716(8.)	0.07262	0.06927	0.0694(14.)	0.0698	0.06970	42
43	0.07180	0.0715(5.)	0.07260	0.06911	0.0691(5.)	0.0698	0.06965	43
44	0.07164	0.0717(6.)	0.07258	0.06895	0.0692(7.)	0.0697	0.06959	44
45	0.07149	0.0719(6.)	0.07256	0.06879	0.0695(11.)	0.0697	0.06953	45
46	0.07134	0.0715(8.)	0.07254	0.06863	0.0684(5.)	0.0696	0.06947	46
47	0.07118	0.0714(7.)	0.07252	0.06846	0.0688(9.)	0.0695	0.06940	47
48	0.07102	0.0710(6.)	0.07151	0.06829	0.0684(7.)	0.0695	0.06856	48
49	0.07086	0.0713(10.)	0.07250	0.06811	0.0672(7.)	0.0694	0.06927	49
50	0.07070	0.0710(12.)	0.07250	0.06793	0.0687(4.)	0.0694		50
51	0.07053	0.0705(4.)	0.07250	0.06774	0.0677(9.)	0.0694		51
52	0.07036	0.0705(12.)	0.07250	0.06754	0.0677(6.)	0.0694		52
53	0.07018	0.0702(10.)	0.07250	0.06734	0.0672(4.)	0.0693		53
54	0.07000	0.0708(8.)		0.06713	0.0681(5.)	0.0693		54
55	0.06981	0.0695(12.)		0.06691	0.0666(5.)	0.0692		55
56	0.06962	0.0698(12.)		0.06669	0.0670(5.)	0.0692		56
57	0.06942	0.0692(7.)		0.06645	0.0665(8.)	0.0691		57
58	0.06922	0.0690(5.)		0.06621	0.0660(7.)	0.0690		58
59	0.06902	0.0690(5.)		0.06596	0.0658(7.)	0.0689		59
60	0.06880	0.0684(6.)		0.06570	0.0650(6.)	0.0688		60
61	0.06859	0.0685(2.)		0.06543	0.0641(20.)	0.0687		61
62	0.06836	0.0683(4.)		0.06515	0.0657(8.)	0.0686		62

Table 3. continued

m	N ₂ broadening			air broadening				m
	smoothed	measured	Lacome et al. ^a	smoothed	measured	HITRAN ^b	Lacome et al. ^c	
63	0.06813	0.0679(4.)		0.06486	0.0650(9.)	0.0686		63
64	0.06790	0.0676(4.)		0.06456		0.0686		64
65	0.06767	0.0681(4.)		0.06426		0.0686		65
66	0.06742	0.0678(4.)		0.06394		0.0686		66
67	0.06718	0.0669(5.)		0.06362	0.0630(11.)	0.0686		67
68	0.06693	0.0668(6.)		0.06329	0.0644(15.)	0.0686		68
69	0.06668	0.0662(4.)		0.06295		0.0686		69
70	0.06643			0.06260		0.0686		70
71	0.06617	0.0665(7.)		0.06224		0.0686		71
72	0.06591	0.0661(10.)		0.06188	0.0618(20.)	0.0686		72
73	0.06565	0.0657(10.)		0.06151		0.0686		73
74	0.06539			0.06114		0.0686		74
75	0.06514			0.06076		0.0686		75
76	0.06488			0.06037		0.0686		76

a. taken from smoothed values given in ref. 3

b. taken from values given for the v₃ band of N₂O in ref. 4c. computed from smoothed values of N₂ and O₂ broadening coefficients given in ref. 3the computed values were derived from the expression: b°(air) = 0.78b°(N₂) + 0.22b°(O₂)
values given within parentheses are estimated uncertainties in the last digit(s)

Table 4. Observed, smoothed and computed values of N_2 - and air-broadening half-width, b° , and frequency-shift, d° , coefficients^a of N_2O obtained in this study.

computed position ^b	line	half-width coefficient, b°				frequency-shift coefficient, d°				upper state ^c	lower state ^c	mol.
		N_2 broadening observed	N_2 broadening smoothed	air broadening observed	air broadening smoothed	N_2 broadening observed	N_2 broadening computed	air broadening observed	air broadening computed			
1864.71240	P18	79.9(10.)	78.8	72.6(15.)	76.1	- .77(8.)	-1.16	-1.00(30.)	-1.33	11101	00001	446
2140.08786	P39	70.6(20.)	72.4	67.8(13.)	69.8	-3.35(60.)	-2.33	-3.56(15.)	-2.37	00011	00001	456
2146.51603	P33	74.5(4.)	73.5	72.2(5.)	70.8	-2.08(15.)	-2.08	-1.70(30.)	-2.16	00011	00001	456
2151.28114	P68	67.2(3.)	66.9	64.4(15.)	63.3	-2.00(12.)	-3.60	-2.30(30.)	-3.46	00011	00001	446
2151.69394	P28	74.4(5.)	74.7	71.1(8.)	72.0	-2.12(15.)	-1.87	-2.21(20.)	-1.98	00011	00001	456
2158.66858	P21	76.5(8.)	77.3	75.0(5.)	74.6	-1.94(35.)	-1.57	-2.22(20.)	-1.72	00011	00001	456
2158.92292	P62	68.3(3.)	68.4	65.7(5.)	65.2	-2.25(30.)	-3.35	-2.24(8.)	-3.25	00011	00001	446
2164.39095	P15	80.7(5.)	80.7	78.1(4.)	78.1	-2.45(15.)	-1.32	-2.62(15.)	-1.51	00011	00001	456
2165.32163	P14	83.3(8.)	81.5	80.6(15.)	78.8	-1.95(10.)	-1.28	-2.13(30.)	-1.47	00011	00001	456
2259.98982	R56	69.3(5.)	69.4	66.0(7.)	66.4	-4.07(10.)	-3.23	-4.36(30.)	-3.16	00011	00001	446
2260.42098	R57	69.2(3.)	69.2	66.7(8.)	66.2	-3.98(12.)	-3.27	-4.15(45.)	-3.20	00011	00001	446
2260.84501	R58	69.0(4.)	69.0	65.2(15.)	66.0	-3.98(15.)	-3.31	-4.17(30.)	-3.23	00011	00001	446
2261.67170	R60	68.5(2.)	68.6	64.1(20.)	65.4	-3.89(8.)	-3.40	-3.66(40.)	-3.31	00011	00001	446
2262.46986	R62	67.9(4.)	68.1	65.0(9.)	64.9	-3.88(20.)	-3.49	-3.96(30.)	-3.38	00011	00001	446
2263.98051	R66	66.9(4.)	67.2	63.1(10.)	63.6	-3.70(30.)	-3.66	-3.41(25.)	-3.53	00011	00001	446
2265.70789	R71	66.1(10.)	65.9	61.8(20.)	61.9	-3.70(20.)	-3.88	-2.64(18.)	-3.72	00011	00001	446
2424.25558	P43	71.2(12.)	71.8	67.9(20.)	69.1	-2.20(40.)	-2.78	-2.50(50.)	-2.80	12001	00001	446
2425.18011	P42	70.4(4.)	71.9	67.0(4.)	69.3	-2.02(25.)	-2.73	-1.56(9.)	-2.76	12001	00001	446
2427.02109	P40	72.0(4.)	72.3	69.6(7.)	69.6	-1.92(30.)	-2.65	-2.17(45.)	-2.69	12001	00001	446
2427.93762	P39	71.1(6.)	72.4	68.3(14.)	69.8	-1.49(15.)	-2.61	-1.80(5.)	-2.65	12001	00001	446
2428.85157	P38	72.4(7.)	72.6	68.9(3.)	69.9	-1.58(15.)	-2.57	-1.61(25.)	-2.62	12001	00001	446
2429.76298	P37	72.8(8.)	72.8	70.3(14.)	70.1	- .71(55.)	-2.52	- .80(40.)	-2.58	12001	00001	446
2431.57833	P35	72.0(3.)	73.1	69.7(4.)	70.4	-1.48(10.)	-2.44	-1.49(25.)	-2.51	12001	00001	446
2432.48235	P34	72.6(5.)	73.3	70.5(5.)	70.6	-1.62(10.)	-2.40	-1.77(30.)	-2.47	12001	00001	446
2433.38398	P33	72.9(6.)	73.5	70.1(6.)	70.8	-1.98(10.)	-2.35	-2.19(17.)	-2.43	12001	00001	446
2440.51548	P25	75.3(6.)	75.6	72.6(4.)	73.0	-2.25(20.)	-2.01	-2.26(22.)	-2.14	12001	00001	446
2441.39724	P24	75.7(3.)	76.0	72.9(4.)	73.3	-2.15(18.)	-1.97	-2.06(15.)	-2.11	12001	00001	446
2442.27696	P23	76.2(4.)	76.4	73.5(4.)	73.7	-1.97(20.)	-1.93	-2.06(8.)	-2.07	12001	00001	446
2443.15466	P22	76.8(4.)	76.8	74.2(4.)	74.1	-1.97(15.)	-1.89	-2.11(9.)	-2.04	12001	00001	446
2444.03037	P21	77.1(3.)	77.3	74.4(4.)	74.6	-1.98(15.)	-1.85	-2.15(7.)	-2.00	12001	00001	446
2444.90412	P20	77.5(3.)	77.7	74.6(6.)	75.1	-1.95(10.)	-1.80	-2.01(7.)	-1.96	12001	00001	446
2445.77594	P19	77.9(5.)	78.2	74.7(6.)	75.6	-1.86(15.)	-1.76	-1.83(5.)	-1.93	12001	00001	446
2446.64584	P18	78.4(8.)	78.8	75.3(4.)	76.1	-2.04(15.)	-1.72	-1.98(12.)	-1.89	12001	00001	446
2447.51385	P17	78.8(3.)	79.4	76.4(4.)	76.7	-1.79(10.)	-1.68	-1.94(6.)	-1.85	12001	00001	446
2448.38000	P16	80.2(3.)	80.0	77.6(3.)	77.4	-1.38(7.)	-1.63	-1.31(9.)	-1.82	12001	00001	446
2449.24430	P15	80.7(5.)	80.7	78.4(4.)	78.1	-1.98(20.)	-1.59	-2.04(25.)	-1.78	12001	00001	446
2450.10677	P14	81.9(5.)	81.5	79.5(3.)	78.8	-2.33(14.)	-1.55	-2.41(10.)	-1.74	12001	00001	446
2450.96743	P13	82.4(4.)	82.3	80.0(4.)	79.7	-2.04(9.)	-1.51	-2.11(9.)	-1.71	12001	00001	446
2451.82630	P12	83.4(4.)	83.2	80.9(3.)	80.5	-1.91(7.)	-1.46	-1.97(9.)	-1.67	12001	00001	446
2452.68338	P11	84.6(3.)	84.1	81.9(4.)	81.5	-1.97(12.)	-1.42	-2.17(4.)	-1.64	12001	00001	446
2453.53870	P10	84.9(3.)	85.1	82.3(4.)	82.5	-2.04(4.)	-1.38	-2.06(7.)	-1.60	12001	00001	446
2454.39226	P 9	86.6(3.)	86.1	83.6(5.)	83.6	-1.87(3.)	-1.34	-1.95(6.)	-1.56	12001	00001	446
2455.24408	P 8	87.6(4.)	87.3	84.8(7.)	84.7	-1.90(5.)	-1.29	-1.87(12.)	-1.53	12001	00001	446
2456.09416	P 7	88.5(4.)	88.5	85.6(3.)	86.0	-1.82(30.)	-1.25	-1.59(18.)	-1.49	12001	00001	446
2456.94251	P 6	90.3(8.)	89.9	87.2(6.)	87.3	-1.23(5.)	-1.21	-1.03(18.)	-1.45	12001	00001	446
2457.78913	P 5	89.5(11.)	91.3	86.5(4.)	88.8	-1.74(6.)	-1.17	-1.48(20.)	-1.42	12001	00001	446
2458.63403	P 4	92.4(4.)	92.8	90.2(15.)	90.4	-3.01(20.)	-1.12	-3.03(22.)	-1.38	12001	00001	446
2459.47721	P 3	93.4(5.)	94.5	91.7(10.)	92.0	-3.85(50.)	-1.08	-3.72(30.)	-1.35	12001	00001	446
2465.33119	R 3	92.4(10.)	92.8	89.6(16.)	90.4	1.33(55.)	-1.13	1.20(60.)	-1.39	12001	00001	446
2466.16051	R 4	91.0(5.)	91.3	88.8(8.)	88.8	- .40(20.)	-1.18	- .29(15.)	-1.43	12001	00001	446
2468.63776	R 7	87.5(6.)	87.3	85.3(8.)	84.7	-1.50(60.)	-1.31	-1.73(15.)	-1.54	12001	00001	446
2469.45990	R 8	86.8(10.)	86.1	84.9(6.)	83.6	-1.50(60.)	-1.35	-1.89(6.)	-1.58	12001	00001	446
2470.28020	R 9	85.9(6.)	85.1	83.8(9.)	82.5	-1.65(40.)	-1.40	-1.73(35.)	-1.62	12001	00001	446
2471.09865	R10	85.1(7.)	84.1	82.7(5.)	81.5	-1.43(19.)	-1.44	-1.41(16.)	-1.65	12001	00001	446
2471.91522	R11	83.5(6.)	83.2	81.1(10.)	80.5	-1.07(10.)	-1.48	-1.03(14.)	-1.69	12001	00001	446
2472.72989	R12	81.9(8.)	82.3	79.5(4.)	79.7	-1.25(15.)	-1.53	-1.17(19.)	-1.73	12001	00001	446
2476.77381	R17	78.5(10.)	78.8	76.2(8.)	76.1	-1.54(20.)	-1.75	-1.29(30.)	-1.92	12001	00001	446
2477.57651	R18	78.3(4.)	78.2	75.7(3.)	75.6	-1.85(15.)	-1.79	-1.73(28.)	-1.96	12001	00001	446
2478.37711	R19	77.7(7.)	77.7	75.3(4.)	75.1	-2.04(20.)	-1.63	-1.98(16.)	-2.00	12001	00001	446
2479.17558	R20	77.3(4.)	77.3	74.7(4.)	74.6	-1.93(15.)	-1.88	-2.11(13.)	-2.03	12001	00001	446
2479.97188	R21	76.5(4.)	76.8	73.8(4.)	74.1	-1.95(20.)	-1.92	-2.03(12.)	-2.07	12001	00001	446
2480.76597	R22	75.8(3.)	76.4	73.3(4.)	73.7	-2.00(12.)	-1.97	-1.96(6.)	-2.11	12001	00001	446
2481.55782	R23	75.4(3.)	76.0	72.9(3.)	73.3	-1.86(5.)	-2.01	-1.99(5.)	-2.15	12001	00001	446
2482.34738	R24	75.3(3.)	75.6	72.6(3.)	73.0	-1.91(7.)	-2.05	-1.98(5.)	-2.18	12001	00001	446
2483.13463	R25	74.9(8.)	75.3	72.7(5.)	72.6	-2.04(40.)	-2.10	-2.09(22.)	-2.22	12001	00001	446
2484.70199	R27	73.4(9.)	74.7	71.6(7.)	72.0	-1.75(15.)	-2.19	-1.87(15.)	-2.30	12001	00001	446
2485.48202	R28	74.3(7.)	74.4	71.9(7.)	71.8	-1.55(45.)	-2.23	-1.63(28.)	-2.34	12001	00001	446

Table 4. continued

computed position ^b	line	half-width coefficient, b°						frequency-shift coefficient, d°						upper state ^c	lower state ^c	mol.
		N ₂ broadening observed	N ₂ broadening smoothed	air broadening observed	air broadening smoothed	N ₂ broadening observed	N ₂ broadening computed	air broadening observed	air broadening computed							
2486.25956	R29	73.7(4.)	74.2	71.1(4.)	71.5	-1.80(8.)	-2.27	-1.84(15.)	-2.37	12001	00001	446				
2487.03457	R30	73.7(3.)	73.9	70.6(6.)	71.3	-1.99(25.)	-2.32	-2.10(9.)	-2.41	12001	00001	446				
2488.57681	R32	72.9(10.)	73.5	69.8(10.)	70.8	-1.78(50.)	-2.41	-1.68(30.)	-2.49	12001	00001	446				
2489.34395	R33	72.5(6.)	73.3	69.8(5.)	70.6	-2.03(19.)	-2.45	-2.06(6.)	-2.53	12001	00001	446				
2490.10837	R34	72.9(4.)	73.1	70.2(3.)	70.4	-2.09(20.)	-2.49	-2.04(12.)	-2.56	12001	00001	446				
2490.87003	R35	72.3(3.)	72.9	69.7(4.)	70.3	-1.91(18.)	-2.54	-2.04(14.)	-2.60	12001	00001	446				
2491.62888	R36	72.9(3.)	72.8	70.1(3.)	70.1	-2.10(7.)	-2.58	-2.09(15.)	-2.64	12001	00001	446				
2492.38486	R37	72.1(7.)	72.6	69.3(13.)	69.9	-1.98(15.)	-2.63	-1.89(5.)	-2.68	12001	00001	446				
2493.13794	R38	71.9(4.)	72.4	69.5(3.)	69.8	-1.97(8.)	-2.67	-2.08(20.)	-2.72	12001	00001	446				
2493.88806	R39	71.6(8.)	72.3	69.2(15.)	69.6	-1.47(20.)	-2.71	-1.88(50.)	-2.75	12001	00001	446				
2496.85799	R43	71.7(12.)	71.6	69.2(10.)	68.9	-3.93(50.)	-2.89	-3.67(13.)	-2.90	12001	00001	446				
2499.05197	R46	71.0(15.)	71.2	68.8(14.)	68.5	-1.10(30.)	-3.02	-0.60(50.)	-3.02	12001	00001	446				
2499.77667	R47	72.5(8.)	71.0	68.3(20.)	68.3	-1.31(50.)	-3.07	-1.75(40.)	-3.06	12001	00001	446				
2512.10013	P51	70.6(7.)	70.5	66.9(12.)	67.7	-3.02(25.)	-3.21	-3.03(30.)	-3.18	20001	00001	446				
2513.26598	P50	71.7(10.)	70.7	68.7(8.)	67.9	-2.00(25.)	-3.16	-2.42(10.)	-3.14	20001	00001	446				
2515.57928	P48	73.2(13.)	71.0	68.5(15.)	68.3	-3.53(30.)	-3.08	-3.77(30.)	-3.07	20001	00001	446				
2516.72668	P47	71.9(20.)	71.2	68.4(10.)	68.5	-1.41(20.)	-3.04	-1.44(25.)	-3.04	20001	00001	446				
2517.86788	P46	71.8(10.)	71.3	67.9(6.)	68.6	-2.09(17.)	-3.00	-2.12(40.)	-3.00	20001	00001	446				
2520.13155	P44	71.3(7.)	71.6	68.7(5.)	68.9	-2.50(45.)	-2.91	-2.53(25.)	-2.93	20001	00001	446				
2521.25398	P43	72.2(3.)	71.8	69.3(4.)	69.1	-2.29(10.)	-2.87	-2.19(7.)	-2.89	20001	00001	446				
2522.37011	P42	72.4(4.)	71.9	69.3(4.)	69.3	-2.21(13.)	-2.83	-2.34(19.)	-2.85	20001	00001	446				
2524.58338	P40	72.4(3.)	72.3	69.9(3.)	69.6	-2.47(15.)	-2.74	-2.54(10.)	-2.78	20001	00001	446				
2525.68048	P39	73.0(4.)	72.4	70.1(5.)	69.8	-2.61(10.)	-2.70	-2.66(4.)	-2.75	20001	00001	446				
2528.93338	P36	72.7(5.)	72.9	70.0(5.)	70.3	-2.85(10.)	-2.57	-2.76(18.)	-2.64	20001	00001	446				
2530.00481	P35	72.6(8.)	73.1	69.5(10.)	70.4	-2.84(7.)	-2.53	-2.77(25.)	-2.60	20001	00001	446				
2531.06979	P34	73.5(3.)	73.3	70.8(3.)	70.6	-2.62(8.)	-2.49	-2.69(8.)	-2.57	20001	00001	446				
2532.12829	P33	74.0(4.)	73.5	71.2(5.)	70.8	-2.79(20.)	-2.45	-2.80(7.)	-2.53	20001	00001	446				
2533.18029	P32	73.5(5.)	73.7	71.1(4.)	71.1	-2.52(12.)	-2.41	-2.65(8.)	-2.49	20001	00001	446				
2560.80496	P 3	94.0(5.)	94.5	91.1(3.)	92.0	-2.58(50.)	-1.18	-2.59(7.)	-1.44	20001	00001	446				
2561.65659	P 2	94.5(10.)	96.2	92.5(10.)	93.8	-2.27(58.)	-1.14	-2.23(21.)	-1.41	20001	00001	446				
2564.17065	R 0	99.4(10.)	98.1	96.4(10.)	95.8	-70(50.)	-1.10	-1.18(30.)	-1.37	20001	00001	446				
2564.99505	R 1	95.7(4.)	96.2	93.2(5.)	93.8	-72(20.)	-1.14	-0.88(11.)	-1.41	20001	00001	446				
2588.36987	R34	72.9(4.)	73.1	70.7(7.)	70.4	-3.22(20.)	-2.59	-3.25(30.)	-2.66	20001	00001	446				
2590.12773	R37	72.3(4.)	72.6	69.6(5.)	69.9	-3.18(10.)	-2.72	-3.21(17.)	-2.77	20001	00001	446				
2590.70024	R38	72.3(4.)	72.4	69.5(3.)	69.8	-2.91(7.)	-2.76	-2.89(6.)	-2.81	20001	00001	446				
2591.26606	R39	72.0(4.)	72.3	69.3(3.)	69.6	-2.96(8.)	-2.81	-2.96(8.)	-2.85	20001	00001	446				
2592.92343	R42	71.0(7.)	71.8	68.5(4.)	69.1	-3.07(13.)	-2.94	-3.14(15.)	-2.96	20001	00001	446				
2593.46258	R43	71.1(12.)	71.6	68.5(7.)	68.9	-2.81(15.)	-2.98	-2.88(19.)	-3.00	20001	00001	446				
2593.99509	R44	72.7(7.)	71.5	69.4(6.)	68.8	-3.48(30.)	-3.03	-3.30(50.)	-3.04	20001	00001	446				
2595.04030	R46	70.4(4.)	71.2	67.8(3.)	68.5	-3.05(21.)	-3.11	-3.16(14.)	-3.11	20001	00001	446				
2595.55302	R47	70.2(4.)	71.0	67.8(8.)	68.3	-3.50(40.)	-3.16	-3.20(11.)	-3.15	20001	00001	446				
2597.05190	R50	70.1(5.)	70.5	68.8(11.)	67.7	-3.05(25.)	-3.29	-2.88(9.)	-3.26	20001	00001	446				
2597.53850	R51	69.4(6.)	70.4	67.3(20.)	67.5	-3.44(25.)	-3.33	-3.31(50.)	-3.30	20001	00001	446				
2598.01862	R52	70.6(7.)	70.2	67.6(4.)	67.3	-2.97(15.)	-3.37	-3.03(35.)	-3.34	20001	00001	446				
2598.95952	R54	67.8(12.)	69.8	65.5(10.)	66.9	-3.85(50.)	-3.46	-3.88(30.)	-3.41	20001	00001	446				
2776.40082	P24	74.0(5.)	76.0	71.3(6.)	73.3	-2.70(40.)	-2.29	-3.11(15.)	-2.43	01111	00001	446				
2778.36637	P22	76.9(5.)	76.8	75.9(5.)	74.1	-1.31(30.)	-2.21	-1.03(35.)	-2.36	01111	00001	446				
2788.71887	P11	83.5(12.)	84.1	82.3(10.)	81.5	-2.15(50.)	-1.74	-2.41(15.)	-1.96	01111	00001	446				
2804.76312	R 7	88.3(10.)	87.3	85.7(15.)	84.7	-65(20.)	-1.63	-1.20(30.)	-1.86	01111	00001	446				
2805.54266	R 8	86.3(5.)	86.1	84.3(8.)	83.6	-1.49(17.)	-1.67	-2.27(30.)	-1.90	01111	00001	446				
2809.34249	R13	82.3(7.)	81.5	79.3(13.)	78.8	-1.42(18.)	-1.89	-1.33(25.)	-2.09	01111	00001	446				
2810.08284	R14	81.8(9.)	80.7	78.3(15.)	78.1	-3.24(12.)	-1.93	-3.82(6.)	-2.13	01111	00001	446				
2811.54390	R16	79.8(5.)	79.4	76.9(10.)	76.7	-2.89(30.)	-2.02	-2.77(15.)	-2.21	01111	00001	446				
2812.26460	R17	78.3(7.)	78.8	73.8(7.)	76.1	-2.37(18.)	-2.07	-2.19(18.)	-2.24	01111	00001	446				
2812.97873	R18	78.1(12.)	78.2	75.1(3.)	75.6	-2.49(25.)	-2.11	-2.55(17.)	-2.28	01111	00001	446				
2813.68630	R19	77.5(3.)	77.7	75.6(5.)	75.1	-1.95(35.)	-2.15	-2.29(14.)	-2.32	01111	00001	446				
2814.38729	R20	77.6(3.)	77.3	74.7(4.)	74.6	-3.17(18.)	-2.20	-2.64(17.)	-2.36	01111	00001	446				
2815.08171	R21	76.4(5.)	76.8	73.2(4.)	74.1	-2.61(20.)	-2.24	-2.91(30.)	-2.39	01111	00001	446				
2815.76955	R22	75.6(7.)	76.4	73.7(4.)	73.7	-2.40(12.)	-2.29	-2.94(30.)	-2.43	01111	00001	446				
2816.45080	R23	75.5(3.)	76.0	73.4(6.)	73.3	-2.37(18.)	-2.33	-2.02(27.)	-2.47	01111	00001	446				
2817.12545	R24	75.8(4.)	75.6	72.2(5.)	73.0	-3.06(22.)	-2.37	-2.83(35.)	-2.51	01111	00001	446				
2817.79351	R25	74.9(4.)	75.3	72.7(4.)	72.6	-2.30(45.)	-2.42	-2.30(8.)	-2.55	01111	00001	446				
2818.45496	R26	74.5(13.)	75.0	71.8(5.)	72.3	-2.70(15.)	-2.46	-1.92(30.)	-2.58	01111	00001	446				
2819.10981	R27	75.5(4.)	74.7	71.8(6.)	72.0	-2.94(12.)	-2.50	-3.18(25.)	-2.62	01111	00001	446				
2819.75805	R28	73.6(6.)	74.4	71.5(6.)	71.8	-2.68(45.)	-2.55	-2.88(30.)	-2.66	01111	00001	446				
2820.39966	R29	74.4(7.)	74.2	70.8(6.)	71.5	-2.98(14.)	-2.59	-3.25(8.)	-2.70	01111	00001	446		</		

Table 4. continued

computed position ^b	line	half-width coefficient, b ^o						frequency-shift coefficient, d ^o						upper state ^c	lower state ^c	mol.
		N ₂ broadening		air broadening		N ₂ broadening		air broadening		observed		computed				
		observed	smoothed	observed	smoothed	observed	computed	observed	computed	observed	computed	observed	computed			
2824.70522	R36	71.8(11.)	72.8	69.7(20.)	70.1	-2.81(60.)	-2.90	-2.33(40.)	-2.96	01111	00001	446				
3325.44227	P41	72.2(18.)	72.1	69.4(8.)	69.4	-3.90(50.)	-3.55	-3.15(30.)	-3.59	02011	00001	446				
3329.60124	P37	72.5(4.)	72.8	71.1(10.)	70.1	-1.33(45.)	-3.38	-1.98(30.)	-3.45	02011	00001	446				
3331.64590	P35	74.2(18.)	73.1	73.3(9.)	70.4	-4.12(30.)	-3.30	-4.45(26.)	-3.38	02011	00001	446				
3332.65966	P34	71.2(16.)	73.3	68.4(10.)	70.6	-3.04(20.)	-3.25	-3.47(26.)	-3.34	02011	00001	446				
3333.66778	P33	73.6(8.)	73.5	71.3(4.)	70.8	-2.30(60.)	-3.21	-2.35(30.)	-3.30	02011	00001	446				
3337.64449	P29	75.8(10.)	74.4	73.5(6.)	71.8	-3.50(50.)	-3.04	-3.57(27.)	-3.16	02011	00001	446				
3338.62493	P28	73.6(6.)	74.7	71.6(6.)	72.0	-2.53(15.)	-3.00	-2.83(22.)	-3.12	02011	00001	446				
3339.59995	P27	73.1(7.)	75.0	70.6(4.)	72.3	-3.12(15.)	-2.96	-3.26(8.)	-3.09	02011	00001	446				
3340.56958	P26	74.4(7.)	75.3	71.6(9.)	72.6	-4.61(20.)	-2.91	-4.73(27.)	-3.05	02011	00001	446				
3341.53386	P25	75.1(5.)	75.6	72.9(4.)	73.0	-2.55(18.)	-2.87	-2.73(12.)	-3.01	02011	00001	446				
3343.44650	P23	76.8(4.)	76.4	74.2(3.)	73.7	-3.25(5.)	-2.79	-3.24(9.)	-2.94	02011	00001	446				
3344.39492	P22	75.6(6.)	76.8	73.1(6.)	74.1	-2.68(15.)	-2.75	-2.79(11.)	-2.91	02011	00001	446				
3345.33813	P21	77.7(11.)	77.3	75.3(8.)	74.6	-3.08(20.)	-2.70	-3.18(23.)	-2.87	02011	00001	446				
3346.27613	P20	76.2(6.)	77.7	74.6(4.)	75.1	-2.74(18.)	-2.66	-2.75(10.)	-2.83	02011	00001	446				
3347.20898	P19	78.8(3.)	78.2	75.9(3.)	75.6	-2.68(30.)	-2.62	-3.24(10.)	-2.80	02011	00001	446				
3349.97677	P16	80.3(4.)	80.0	78.3(6.)	77.4	-2.95(15.)	-2.49	-3.13(9.)	-2.69	02011	00001	446				
3350.88921	P15	80.7(5.)	80.7	78.6(13.)	78.1	-2.86(12.)	-2.45	-2.96(12.)	-2.65	02011	00001	446				
3351.79659	P14	81.8(6.)	81.5	79.1(4.)	78.8	-3.54(12.)	-2.41	-3.21(23.)	-2.62	02011	00001	446				
3352.69895	P13	82.8(6.)	82.3	79.8(3.)	79.7	-2.68(12.)	-2.36	-2.45(8.)	-2.58	02011	00001	446				
3356.25845	P 9	85.9(7.)	86.1	82.8(6.)	83.6	-2.40(25.)	-2.20	-2.39(28.)	-2.43	02011	00001	446				
3357.13590	P 8	86.8(6.)	87.3	85.0(10.)	84.7	-2.23(20.)	-2.15	-2.48(6.)	-2.40	02011	00001	446				
3358.87599	P 6	89.1(3.)	89.9	86.4(5.)	87.3	-2.10(5.)	-2.07	-1.97(22.)	-2.33	02011	00001	446				
3367.28070	R 3	90.8(8.)	92.8	88.0(7.)	90.4	-1.35(30.)	-1.99	-.96(27.)	-2.26	02011	00001	446				
3369.70563	R 6	87.3(15.)	88.5	85.8(12.)	86.0	-1.47(30.)	-2.12	-1.50(25.)	-2.37	02011	00001	446				
3371.29724	R 8	85.4(14.)	86.1	81.9(18.)	83.6	-1.80(50.)	-2.21	-1.56(24.)	-2.45	02011	00001	446				
3372.08548	R 9	84.4(10.)	85.1	81.8(10.)	82.5	-1.85(30.)	-2.25	-1.69(19.)	-2.49	02011	00001	446				
3372.86865	R10	84.0(10.)	84.1	81.9(3.)	81.5	-1.82(20.)	-2.30	-1.50(30.)	-2.52	02011	00001	446				
3373.64674	R11	83.3(4.)	83.2	80.8(4.)	80.5	-2.08(15.)	-2.34	-2.07(12.)	-2.56	02011	00001	446				
3374.41971	R12	82.1(4.)	82.3	79.8(3.)	79.7	-1.68(25.)	-2.39	-2.01(10.)	-2.60	02011	00001	446				
3375.18754	R13	81.1(5.)	81.5	79.0(3.)	78.8	-2.53(24.)	-2.43	-2.61(15.)	-2.64	02011	00001	446				
3375.95019	R14	81.8(7.)	80.7	78.4(3.)	78.1	-1.86(8.)	-2.47	-2.02(24.)	-2.68	02011	00001	446				
3376.70765	R15	80.9(4.)	80.0	78.4(3.)	77.4	-2.78(20.)	-2.52	-2.90(10.)	-2.71	02011	00001	446				
3377.45988	R16	79.1(3.)	79.4	76.2(4.)	76.7	-2.28(7.)	-2.56	-2.26(9.)	-2.75	02011	00001	446				
3378.20685	R17	78.5(5.)	78.8	75.9(4.)	76.1	-2.49(7.)	-2.60	-2.27(18.)	-2.79	02011	00001	446				
3378.94853	R18	78.5(4.)	78.2	76.3(3.)	75.6	-2.15(13.)	-2.65	-2.31(19.)	-2.83	02011	00001	446				
3379.68487	R19	77.7(4.)	77.7	75.2(3.)	75.1	-2.54(8.)	-2.69	-2.72(20.)	-2.87	02011	00001	446				
3380.41584	R20	77.4(3.)	77.3	75.2(3.)	74.6	-2.82(5.)	-2.74	-2.84(22.)	-2.90	02011	00001	446				
3381.14142	R21	76.5(3.)	76.8	73.9(4.)	74.1	-2.64(28.)	-2.78	-2.96(20.)	-2.94	02011	00001	446				
3381.86155	R22	75.9(9.)	76.4	73.0(4.)	73.7	-2.70(18.)	-2.82	-2.84(12.)	-2.98	02011	00001	446				
3382.57619	R23	75.7(4.)	76.0	73.2(3.)	73.3	-2.65(14.)	-2.87	-2.73(12.)	-3.02	02011	00001	446				
3383.28531	R24	75.4(3.)	75.6	72.6(5.)	73.0	-2.74(24.)	-2.91	-2.82(12.)	-3.05	02011	00001	446				
3383.98887	R25	74.9(8.)	75.3	72.6(4.)	72.6	-2.80(6.)	-2.96	-3.01(11.)	-3.09	02011	00001	446				
3384.68681	R26	74.5(4.)	75.0	72.2(3.)	72.3	-2.89(18.)	-3.00	-2.74(9.)	-3.13	02011	00001	446				
3385.37910	R27	74.1(3.)	74.7	71.5(4.)	72.0	-3.18(14.)	-3.04	-3.35(18.)	-3.17	02011	00001	446				
3386.06569	R28	74.3(6.)	74.4	71.9(4.)	71.8	-2.70(16.)	-3.09	-2.96(25.)	-3.21	02011	00001	446				
3386.74654	R29	73.6(6.)	74.2	71.7(6.)	71.5	-2.98(30.)	-3.13	-2.79(35.)	-3.24	02011	00001	446				
3387.42159	R30	74.3(5.)	73.9	70.9(10.)	71.3	-2.92(10.)	-3.18	-3.07(6.)	-3.28	02011	00001	446				
3388.09081	R31	74.8(4.)	73.7	72.1(5.)	71.1	-2.22(25.)	-3.22	-2.27(25.)	-3.32	02011	00001	446				
3388.75413	R32	72.6(4.)	73.5	69.8(4.)	70.8	-2.88(20.)	-3.26	-3.00(30.)	-3.36	02011	00001	446				
3389.41152	R33	74.2(5.)	73.3	72.0(5.)	70.6	-3.77(15.)	-3.31	-4.17(25.)	-3.39	02011	00001	446				
3390.06292	R34	74.1(8.)	73.1	71.8(6.)	70.4	-2.40(40.)	-3.35	-1.90(40.)	-3.43	02011	00001	446				
3390.70829	R35	75.1(4.)	72.9	71.8(8.)	70.3	-4.15(25.)	-3.39	-4.03(30.)	-3.47	02011	00001	446				
3391.34757	R36	72.8(6.)	72.8	70.2(8.)	70.1	-3.38(10.)	-3.44	-4.05(40.)	-3.51	02011	00001	446				
3391.98072	R37	74.8(8.)	72.6	71.4(10.)	69.9	-3.80(60.)	-3.48	-3.23(20.)	-3.55	02011	00001	446				
3430.20251	P47	73.0(8.)	71.2	70.4(6.)	68.5	-2.90(28.)	-3.91	-3.30(30.)	-3.92	10011	00001	446				
3431.54801	P46	71.8(8.)	71.3	68.5(7.)	68.6	-3.58(8.)	-3.87	-3.74(6.)	-3.88	10011	00001	446				
3439.20274	P40	72.3(7.)	72.3	69.8(4.)	69.6	-3.54(20.)	-3.61	-3.83(25.)	-3.67	10011	00001	446				
3440.44387	P39	73.3(9.)	72.4	70.7(3.)	69.8	-3.58(30.)	-3.57	-3.76(25.)	-3.63	10011	00001	446				
3444.10615	P36	73.4(8.)	72.9	71.3(7.)	70.3	-3.84(10.)	-3.45	-3.96(27.)	-3.52	10011	00001	446				
3445.30633	P35	75.0(6.)	73.1	71.7(9.)	70.4	-3.95(30.)	-3.40	-4.15(10.)	-3.49	10011	00001	446				
3446.49649	P34	75.3(9.)	73.3	72.4(6.)	70.6	-3.15(10.)	-3.36	-3.36(18.)	-3.45	10011	00001	446				
3479.13271	P 2	94.5(9.)	96.2	93.5(10.)	93.8	-2.30(40.)	-2.01	-2.73(27.)	-2.29	10011	00001	446				
3479.98118	P 1	97.7(10.)	98.1	97.7(10.)	95.8	-2.22(30.)	-1.97	-2.48(25.)	-2.26	10011	00001	446				
3504.45214	R36	72.8(15.)	72.8	69.9(13.)	70.1	-4.64(20.)	-3.55	-4.52(25.)	-3.62	10011	00001	446				
3504.89111	R37	73.2(8.)	72.6	70.8(7.)	69.9	-4.52(20.)	-3.59	-4.50(22.)	-3.65	10011	00001	446				
3505.31960	R38	72.6(7.)	72.4	70.4(10.)	69.8	-4.										

Table 4. continued

computed position ^b	line	half-width coefficient, b°				frequency-shift coefficient, d°				upper state ^c	lower state ^c	mol.
		N ₂ broadening observed	air broadening smoothed	N ₂ broadening observed	air broadening smoothed	N ₂ broadening observed	air broadening computed	N ₂ broadening observed	air broadening computed			
3506.92912	R42	71.5(8.)	71.8	69.3(3.)	69.1	-4.65(20.)	-3.81	-4.53(10.)	-3.84	10011	00001	446
3507.30600	R43	71.5(6.)	71.6	69.0(3.)	68.9	-4.38(5.)	-3.85	-4.35(7.)	-3.88	10011	00001	446
3507.67523	R44	71.6(6.)	71.5	69.1(4.)	68.8	-4.51(20.)	-3.89	-4.18(16.)	-3.92	10011	00001	446
3507.99683	R45	71.7(4.)	71.3	68.4(3.)	68.6	-4.24(5.)	-3.94	-4.10(10.)	-3.95	10011	00001	446
3508.15384	R45	69.4(12.)	71.3	65.4(15.)	68.6	-1.50(50.)	-3.94	-1.50(50.)	-3.95	06001	00001	446
3508.36177	R46	70.9(4.)	71.2	68.3(8.)	68.5	-4.63(25.)	-3.98	-4.52(30.)	-3.99	10011	00001	446
3508.69787	R47	71.4(6.)	71.0	69.0(3.)	68.3	-4.80(12.)	-4.03	-4.68(8.)	-4.03	10011	00001	446
3509.02180	R48	70.9(9.)	70.9	68.1(15.)	68.1	-3.88(17.)	-4.07	-3.98(30.)	-4.07	10011	00001	446
3509.33502	R49	71.4(4.)	70.7	68.6(6.)	67.9	-4.25(16.)	-4.11	-4.42(18.)	-4.10	10011	00001	446
3509.63747	R50	70.3(12.)	70.5	67.7(6.)	67.7	-4.83(25.)	-4.16	-4.77(24.)	-4.14	10011	00001	446
3509.92930	R51	70.5(8.)	70.4	68.2(4.)	67.5	-4.45(25.)	-4.20	-4.49(35.)	-4.18	10011	00001	446
3510.21068	R52	70.3(4.)	70.2	67.3(5.)	67.3	-4.89(21.)	-4.24	-4.97(8.)	-4.22	10011	00001	446
3510.48142	R53	70.8(8.)	70.0	68.3(5.)	67.1	-4.63(12.)	-4.29	-4.80(30.)	-4.25	10011	00001	446
3510.74181	R54	69.1(3.)	69.8	67.0(5.)	66.9	-4.73(30.)	-4.33	-5.00(30.)	-4.29	10011	00001	446
3510.99163	R55	68.4(9.)	69.6	67.5(5.)	66.7	-5.15(50.)	-4.37	-5.04(9.)	-4.33	10011	00001	446
3800.17715	P36	73.5(10.)	72.9	70.7(12.)	70.3	-4.00(40.)	-3.78	-4.05(30.)	-3.87	30001	00001	446
3802.50586	P34	73.8(7.)	73.3	70.2(7.)	70.6	-3.62(25.)	-3.70	-3.67(28.)	-3.79	30001	00001	446
3803.65665	P33	73.5(4.)	73.5	70.9(5.)	70.8	-3.95(35.)	-3.66	-3.39(10.)	-3.76	30001	00001	446
3804.79834	P32	75.1(6.)	73.7	72.3(9.)	71.1	-4.18(18.)	-3.62	-3.80(10.)	-3.72	30001	00001	446
3805.93090	P31	74.5(7.)	73.9	71.2(14.)	71.3	-3.50(40.)	-3.57	-3.67(20.)	-3.69	30001	00001	446
3808.16848	P29	74.6(4.)	74.4	71.9(4.)	71.8	-3.72(25.)	-3.49	-4.02(10.)	-3.61	30001	00001	446
3809.27344	P28	76.0(5.)	74.7	72.7(4.)	72.0	-4.22(25.)	-3.45	-4.39(18.)	-3.58	30001	00001	446
3810.36914	P27	75.7(5.)	75.0	73.5(5.)	72.3	-4.02(25.)	-3.41	-4.16(10.)	-3.54	30001	00001	446
3811.45555	P26	75.9(4.)	75.3	72.9(5.)	72.6	-3.70(10.)	-3.36	-3.85(22.)	-3.50	30001	00001	446
3812.53265	P25	76.1(6.)	75.6	73.3(7.)	73.0	-3.42(8.)	-3.32	-3.67(15.)	-3.47	30001	00001	446
3814.65877	P23	76.8(4.)	76.4	74.5(4.)	73.7	-3.18(25.)	-3.24	-3.48(10.)	-3.40	30001	00001	446
3816.74731	P21	78.4(5.)	77.3	75.6(6.)	74.6	-3.79(20.)	-3.15	-3.98(9.)	-3.32	30001	00001	446
3817.77742	P20	78.7(4.)	77.7	76.0(6.)	75.1	-3.28(17.)	-3.11	-3.38(8.)	-3.29	30001	00001	446
3818.79808	P19	78.8(7.)	78.2	77.3(5.)	75.6	-3.73(26.)	-3.07	-4.02(15.)	-3.25	30001	00001	446
3822.78568	P15	80.7(7.)	80.7	78.6(4.)	78.1	-3.42(15.)	-2.90	-3.37(18.)	-3.11	30001	00001	446
3823.75874	P14	82.2(8.)	81.5	79.8(8.)	78.8	-3.28(22.)	-2.86	-3.27(10.)	-3.07	30001	00001	446
3824.72222	P13	82.6(4.)	82.3	79.5(8.)	79.7	-3.53(17.)	-2.81	-3.80(30.)	-3.03	30001	00001	446
3825.67612	P12	83.6(4.)	83.2	81.0(6.)	80.5	-3.15(35.)	-2.77	-3.24(16.)	-3.00	30001	00001	446
3828.48017	P 9	86.0(9.)	86.1	83.6(15.)	83.6	-3.15(50.)	-2.64	-3.33(10.)	-2.89	30001	00001	446
3830.30137	P 7	88.1(18.)	88.5	85.1(10.)	86.0	-3.20(57.)	-2.56	-2.77(10.)	-2.82	30001	00001	446
3831.19750	P 6	89.5(9.)	89.9	86.7(10.)	87.3	-3.01(40.)	-2.52	-3.31(8.)	-2.78	30001	00001	446
3839.62602	R 3	92.2(13.)	92.8	88.4(10.)	90.4	-1.57(27.)	-2.44	-1.98(25.)	-2.71	30001	00001	446
3840.41550	R 4	90.3(12.)	91.3	86.9(6.)	88.8	-1.75(25.)	-2.48	-1.84(16.)	-2.75	30001	00001	446
3841.96532	R 6	88.7(4.)	88.5	85.8(10.)	86.0	-2.20(25.)	-2.57	-2.23(10.)	-2.83	30001	00001	446
3842.72567	R 7	86.8(15.)	87.3	85.0(4.)	84.7	-2.02(25.)	-2.61	-2.01(10.)	-2.87	30001	00001	446
3845.67001	R11	83.8(8.)	83.2	80.7(6.)	80.5	-2.38(8.)	-2.79	-2.27(15.)	-3.02	30001	00001	446
3847.08401	R13	82.2(5.)	81.5	79.6(4.)	78.8	-2.73(11.)	-2.88	-2.63(25.)	-3.09	30001	00001	446
3847.77649	R14	81.8(4.)	80.7	78.9(5.)	78.1	-2.65(45.)	-2.92	-2.70(25.)	-3.13	30001	00001	446
3848.45930	R15	81.0(0.)	80.0	78.2(5.)	77.4	-2.80(20.)	-2.97	-3.09(18.)	-3.17	30001	00001	446
3849.13245	R16	79.5(4.)	79.4	78.1(5.)	76.7	-2.97(30.)	-3.01	-3.25(10.)	-3.21	30001	00001	446
3850.44982	R18	77.5(18.)	78.2	75.9(5.)	75.6	-3.50(50.)	-3.10	-3.36(20.)	-3.28	30001	00001	446
3851.09405	R19	78.3(4.)	77.7	75.7(5.)	75.1	-3.35(25.)	-3.14	-3.27(10.)	-3.32	30001	00001	446
3851.72867	R20	76.9(10.)	77.3	73.4(10.)	74.6	-3.01(29.)	-3.19	-3.39(19.)	-3.36	30001	00001	446
3852.35368	R21	78.0(20.)	76.8	76.9(15.)	74.1	-2.90(60.)	-3.23	-3.27(30.)	-3.40	30001	00001	446
3852.96912	R22	76.8(8.)	76.4	73.9(6.)	73.7	-3.38(9.)	-3.27	-3.36(8.)	-3.43	30001	00001	446
3855.33532	R26	75.5(8.)	75.0	72.9(5.)	72.3	-3.83(30.)	-3.45	-4.23(10.)	-3.58	30001	00001	446
3855.90309	R27	75.8(10.)	74.7	73.9(6.)	72.0	-3.43(12.)	-3.49	-3.17(8.)	-3.62	30001	00001	446
3856.46139	R28	74.8(5.)	74.4	72.2(6.)	71.8	-3.71(8.)	-3.54	-3.92(9.)	-3.66	30001	00001	446
3857.01023	R29	74.1(8.)	74.2	71.3(12.)	71.5	-3.81(25.)	-3.58	-4.25(50.)	-3.70	30001	00001	446
3858.07968	R31	73.9(6.)	73.7	70.4(5.)	71.1	-3.64(30.)	-3.67	-3.68(14.)	-3.77	30001	00001	446
3858.60033	R32	73.9(6.)	73.5	70.7(4.)	70.8	-3.68(19.)	-3.71	-3.81(10.)	-3.81	30001	00001	446
3859.11164	R33	73.1(7.)	73.3	70.7(8.)	70.6	-4.65(35.)	-3.75	-4.33(7.)	-3.85	30001	00001	446
3859.61364	R34	73.3(9.)	73.1	69.4(7.)	70.4	-4.20(40.)	-3.80	-4.05(20.)	-3.89	30001	00001	446
3860.58982	R36	73.4(6.)	72.8	70.3(4.)	70.1	-3.97(18.)	-3.88	-3.53(25.)	-3.96	30001	00001	446
4381.16019	P34	74.1(15.)	73.3	70.4(9.)	70.6	-3.90(35.)	-4.25	-4.12(26.)	-4.35	00021	00001	446
4384.99397	P31	73.3(12.)	73.9	70.7(5.)	71.3	-4.49(17.)	-4.12	-4.16(40.)	-4.24	00021	00001	446
4388.70465	P28	74.0(14.)	74.7	69.5(8.)	72.0	-4.08(15.)	-4.00	-4.25(50.)	-4.14	00021	00001	446
4389.91416	P27	75.4(8.)	75.0	71.2(8.)	72.3	-4.83(55.)	-3.96	-4.97(18.)	-4.10	00021	00001	446
4391.10998	P26	75.1(4.)	75.3	70.4(8.)	72.6	-3.79(28.)	-3.91	-4.62(30.)	-4.06	00021	00001	446
4393.46051	P24	76.2(13.)	76.0	73.4(10.)	73.3	-3.95(60.)	-3.83	-4.80(30.)	-3.99	00021	00001	446
4394.61521	P23	76.0(4.)	76.4	72.7(4.)	73.7	-3.70(30.)	-3.79	-4.98(30.)	-3.96	00021	00001	446
4399.09677	P19	78.4(5.)	78.2	75.9(6.)	75.6	-4.05(40.)	-3.62	-4.18(30.)	-3.81	00021	00001	446
4400.18284	P18	79.8(7.)	78.8	76.9(10.)	76.1	-4.25(50.)	-3.58	-4.68(27.)	-3.78	00021	00001	446
4401.25516	P17	78.8(6.)	79.4	77.5(10.)	76.7	-4.01(30.)	-3.54	-4.23(19.)	-3.74	00021	00001	446
4407.40026	P11	85.2(14.)	84.1	82.2(15.)	81.5	-3.50(60.)	-3.28	-3.63(18.)	-3.52	00021	00001	446

Table 4. continued

computed position ^b	line	half-width coefficient, b°						frequency-shift coefficient, d°						upper state ^c	lower state ^c	mol.
		N ₂ broadening		air broadening		N ₂ broadening		air broadening		observed		computed				
		observed	smoothed	observed	smoothed	observed	computed	observed	computed	observed	computed	observed	computed	state	state	mol.
4408.37626	P10	84.5(12.)	85.1	83.1(4.)	82.5	-3.46(15.)	-3.24	-4.34(50.)	-3.49	00021	00001	446				
4423.58399	R 7	86.5(10.)	87.3	85.7(5.)	84.7	-2.92(20.)	-3.17	-2.15(30.)	-3.43	00021	00001	446				
4424.29746	R 8	86.0(15.)	86.1	82.8(10.)	83.6	-2.88(60.)	-3.21	-2.33(18.)	-3.46	00021	00001	446				
4425.68283	R10	83.8(8.)	84.1	82.1(6.)	81.5	-2.73(20.)	-3.30	-2.91(50.)	-3.54	00021	00001	446				
4427.01274	R12	83.4(8.)	82.3	79.2(7.)	79.7	-3.49(30.)	-3.39	-2.75(40.)	-3.62	00021	00001	446				
4427.65689	R13	81.8(4.)	81.5	79.1(9.)	78.8	-3.42(10.)	-3.43	-3.75(40.)	-3.65	00021	00001	446				
4428.28715	R14	80.8(4.)	80.7	78.6(12.)	78.1	-3.60(33.)	-3.47	-3.05(29.)	-3.69	00021	00001	446				
4428.90354	R15	80.2(8.)	80.0	76.4(6.)	77.4	-3.17(15.)	-3.52	-3.38(7.)	-3.73	00021	00001	446				
4429.50604	R16	78.9(4.)	79.4	77.9(5.)	76.7	-2.97(25.)	-3.56	-3.48(16.)	-3.77	00021	00001	446				
4430.09465	R17	79.3(4.)	78.8	75.9(10.)	76.1	-2.99(40.)	-3.61	-3.18(30.)	-3.80	00021	00001	446				
4430.66937	R18	78.5(6.)	78.2	75.5(4.)	75.6	-4.27(30.)	-3.65	-3.45(17.)	-3.84	00021	00001	446				
4431.23019	R19	78.6(5.)	77.7	74.9(10.)	75.1	-3.70(50.)	-3.69	-3.90(45.)	-3.88	00021	00001	446				
4431.77711	R20	77.4(7.)	77.3	73.9(5.)	74.6	-4.10(35.)	-3.74	-3.70(12.)	-3.92	00021	00001	446				
4432.31012	R21	76.5(5.)	76.8	75.2(6.)	74.1	-3.50(20.)	-3.78	-3.75(30.)	-3.96	00021	00001	446				
4432.82923	R22	76.6(5.)	76.4	73.4(4.)	73.7	-3.94(25.)	-3.82	-4.81(29.)	-3.99	00021	00001	446				
4433.33443	R23	76.0(4.)	76.0	72.5(12.)	73.3	-4.33(55.)	-3.87	-3.55(27.)	-4.03	00021	00001	446				
4433.82572	R24	74.5(8.)	75.6	72.5(18.)	73.0	-4.41(20.)	-3.91	-3.93(17.)	-4.07	00021	00001	446				
4434.76653	R26	74.6(4.)	75.0	72.2(4.)	72.3	-4.55(8.)	-4.00	-4.92(20.)	-4.14	00021	00001	446				
4435.21605	R27	74.5(15.)	74.7	70.7(10.)	72.0	-4.55(30.)	-4.04	-4.65(50.)	-4.18	00021	00001	446				
4436.07330	R29	73.8(10.)	74.2	70.5(5.)	71.5	-5.80(50.)	-4.13	-4.53(10.)	-4.26	00021	00001	446				
4436.87481	R31	73.4(11.)	73.7	69.2(9.)	71.1	-5.42(50.)	-4.22	-4.54(29.)	-4.33	00021	00001	446				
4720.84974	P11	81.6(20.)	84.1	82.9(15.)	81.5	-2.60(30.)	-3.58	-3.50(30.)	-3.83	20011	00001	446				
4742.35686	R15	81.1(10.)	80.0	76.2(10.)	77.4	-2.62(25.)	-3.82	-3.99(21.)	-4.03	20011	00001	446				
4743.54984	R17	77.3(12.)	78.8	76.5(20.)	76.1	-3.60(30.)	-3.90	-3.50(60.)	-4.11	20011	00001	446				
4746.29081	R22	77.8(10.)	76.4	73.9(5.)	73.7	-3.40(30.)	-4.12	-4.73(35.)	-4.30	20011	00001	446				

a. b° and d° in cm⁻¹/atm. × 10³; measurements taken at 296 K.

b. low pressure ("zero pressure) frequencies from ref.(2)

c. vibrational state notation is as follows: v₁v₂lv₃s, where s=1 for e and s=2 for f.

values given within parentheses are estimated uncertainties in the last digit(s)







